Int.J.Curr.Res.Aca.Rev; **Special Issue-2 (January-2015) : 49-55**

EXCELLENT PUBLISHERS

International Journal of Current Research and Academic Review

ISSN: 2347-3215 Special Issue-2 (January-2015) pp. 49-55

www.ijcrar.com

The effects muscle activities at constant illuminance with multiple temperatures for rubber scrap industries

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KEYWORDS

Illuminance,
Temperature,
Muscle activities,
Muscle fatigue,
Electromyography

A B S T R A C T

In the industrial sector, most workers perform repetitive loading and unloading tasks which majorly contribute to muscle fatigue to workers that affect their performance. The purpose of this study was to determine the effect of muscle activity associated with ergonomic parameters such as illuminance and temperature through the task of loading and unloading in the rubber industry in Malaysia. This study was conducted in the actual workplace and laboratory simulations involving the use of measuring temperature and illuminance. Meanwhile, a total of six respondents were selected and fitted with Electromyography (EMG) for muscle fatigue measurement on the right and left body side of employees. The data collected is analyzed to find out the correlation relationship within right body and left body. From the study, the dominant temperature 24°C is most suitable temperature level for the workers to perform their task while illuminance setting 200 lux has slightly effective on muscle fatigue.

Introduction

Ergonomic is widely concerned by most of the employers nowadays which ergonomic covers most of the occupational hazards that related to workplace environment, at the same time, good workplace environment brings good impacts on human performance such as increasing their concentration, productivity, job satisfaction and enhance workplace safety indirectly (Health and Safety Executive, 2013). Therefore, good workplace environments are anticipated by most of the workers in industries such as sufficient illuminance level and moderate temperature which are important elements in ergonomic field. Illuminance is one of the ergonomic factors that is important for human as it enables them to perform their visual activities. People have relied mainly on illuminance and fire since thousand years ago. General illuminance enhances people to

perform their task with basic lighting requirement at their workplace such as support the performance of a visual task and attract attention of workers (Mclean, 2004). Illuminance can affect humans psychologically and physiologically such as low illumination can cause eyestrain to the workers that need high level of illumination and affect the emotion of workers indirectly (Boyce, 2003). According to Choi et al. (2013), they concluded that sunlight illuminance is vital factor and positively related to indoor environmental quality and work efficiency or productivity. In addition, Lah, Zupancˇicˇ et al. (2006) stated that using illuminance can reduce energy consumption and increase the satisfaction of workers. Poor lighting can affects the health of people such as causing eyestrain, migraine and headache, and it is also can contribute to Sick Building Syndrome (HSE, 1997). Eyestrain is a kind of muscle activity in eyes, which means there is a relationship between illuminance and muscle activity.

In addition, Malaysia is a tropical country which has a warm and humid climate (MOSTI, 2012). Therefore, temperature and relative humidity in the workplace are key factors to affect the human performance in the workplace too. The humidity in Malaysia is approximately 80% all the year and climatic temperature is range from 21 to 32°C. According to Talty (2005), temperature is referred to degree of heat intensity measurement or hotness of the object, whereas heat is energy measurement in terms of quantity. Temperature too high or too low can cause discomfort which is heat stress to the workers (CDC, 2012). Other than that, Talty (2003) also defined that relative humidity is the amount of moisture content in the air compared with amount that the air could contain at saturation at the same temperature (CDC, 2012). Moreover, Ismail *et al.* (2009) concluded that temperature and relative humidity can affect the perception of comfortable level of workers in the workplace and influence the productivity indirectly.

Other than that, Electromyography is extensively used in testing muscle fatigue. There are words to define muscle fatigue. Öberg (1995) mentioned that muscle fatigue have various meaning, like impaired motor performance and force generation, and EMG amplitude increased by muscular load (Drewes, 2000). In addition, he found that amplitude and spectral parameters showed the influences of fatigue. He also concluded that increased amplitude (which cause muscle fatigue) is caused by elevated external load. In the other hand, this study is conducted to study the effect of illuminance and temperature on human physiology performance, which is more on muscle activities. Muscle activities can be detected by electromyography (EMG) which is technique that used to detect and recording the electrical activity produced by skeletal muscles (Öberg, 1995) by placing the electrode on the skin surface and its influence to the productivity such as loading and unloading the 25kg task in this study. Then EMG signal is recorded to indicate when muscles are activated during tasks.

Method of Study

An experimental study was carried out to assess the effects of illuminance and temperature on human performance in rubber industry. For this reason, six respondents were selected from various demographic data to be analysed of muscle activities recorded by electromyography (EMG) equipment simultaneously. The method of data collection was gathered from the location as actual condition in rubber industries that performed repetitive loading

and unloading task. Then, all respondance were performed their repetitive loading and unloading task in the ergonomic simulation test with setting parameter as shown in Table 1.

The EMG located on the upper body which is right trapezius, right biceps brachii, left trapezius, and left biceps brachii. In this study, every respondent will performed task of loading and unloading a 25kg load repetitively under stipulated temperature and illuminance parameter setting. Each parameter comes with six times trials which each trial carries five minutes of duration and it was approximately seven times per trial as shown in Figure 1. On average, there are seven movements that have been captured within a five minutes time interval for every respondent under specified parameter.

All dimensional data for EMG reading was tabled to transfer into graphical view. Furthermore, correlation relationship for right body (right biceps brachii to right trapezius) and correlation relationship of left body (left biceps brachii to left trapezius) were analysed according to data gathered.

Result and Discussion

The results include the data of the EMG signal produced by the muscles with different parameters. Then, correlation relationship tests were tested for right trapezius to right biceps brachii and left trapezius to left biceps brachii followed by the results will be utilized as a basis for recommendation for changes in the design of illuminance level and temperature in rubber industry. The experimental data of EMG reading of right biceps brachii, right trapezius, left biceps brachii and left trapezius that obtained during the laboratory experiment at constant illuminance against the dominant setting temperature as shown in Figure 2. From the Figure, it can see that the highest EMG signal produced by each part of the respondent is left biceps brachii of every respondent. Then, it is obviously that the rest muscles which are right trapezius followed by left trapezius and right biceps was indicated the level of muscle activity for each position simultaneously with the task. All of the respondents are right handed, therefore, they seldom use their left hands to handle thing. Thus, left hands may dedicate more energy while loading and unloading. According to Norman and Wells (1998), they concluded that muscle fatigue can be happened in poor workplace environment to the workers such as lock back pain.

Furthermore, the Figure 3a also determine that right trapeziues and left trapezius produced moderate EMG signal while the right biceps brachii exert the less energy. Right handed respondents have less power to load and unloading the task. Thus, left bicep brachii used more energy than right bicep brachii. Öberg (1995) argued that when EMG amplitude is increased during elevated external load, it will caused a muscle fatigue for person. Since the muscle of worker gets fatigue, the moving will decreased as well as they start to slow down to perform the task. On Figure 3b shows the highest value of EMG signal produced by all the respondents is left biceps brachii. Besides that, right trapeziues and left trapezius produced moderate EMG signal while the right biceps brachii exert the less energy. Right handed respondents have less power to load and unloading the task. Thus, left bicep brachii used more energy than right bicep brachii. In addition, Figure 3c shows the findings of EMG reading of muscle part of respondents such as right biceps brachii, right trapezius, left biceps brachii and left trapezius that obtained

during the laboratory experiment (loading and unloading 25 load) at constant temperature at 19°C and illuminance at 200lux. In that Figure, the EMG reading for left biceps brachii and right trapezius for the first three respondents is almost average. However, the EMG reading for left biceps brachii and right trapezius for the last three respondents is slightly different, the left biceps bracii take more role than right trapezius. Other than that, the left trapezius EMG reading for every respondent carries the lowest EMG signal. Thus, this shows that left trapezius give least energy during unloading and loading in this condition. Other than that, Dimitrova and Dimitrova (2002) stated that failure to maintain the needed or estimated force is considered as muscle failure. The workers may start shivering and failure to maintain the force to load the task at very low temperature which is considered as muscle fatigue.

The correlation significant of right body and left body side as shown in Table 2 obtained at temperature 32°C have stronger correlation strength compare to correlation relationship of left and right body at temperature 24°C and 19°C. At temperature 32°C, it is a quite warm temperature for workers to perform their task. During conducting the experiments, the workers tended to sweating more at 32°C compare to temperature 24°C and 19°C. From the sweating criteria of workers and the results shown, it can be said that muscles produced more energy at temperature 32°C and it may cause the workers get fatigue easily compare to the temperature 24°C and temperature 19°C. To prevent heat stress, the most suitable way to perform the work task is to compliance with ISO 7236, at temperature 28°C to 28.5°C. At temperature 19°C, the correlation relationship of the right and left body side of the body has very low correlation strength which shows that the muscles activity of the respondents is very low at a cold temperature. In a nutshell, temperature too high or too low may cause muscle fatigue to the workers. Therefore, a moderate temperature like room temperature (24°C) is recommended to the workers. Other than that, illuminance in this research doesn't affect the muscle activities apparently maybe with reason that the task doesn't require a high illuminance to for visual performance.

Conclusion

To study the effects of illuminance and temperature on muscle activities, the laboratory experiment was conducted. The final result from the overall findings is significant to achieve the objectives of this research. From the discussion, temperature too high (32°C) or too low (19°C) cause the muscles activities is higher compare to muscle activities at moderate temperature 24°C when the task is same for all the respondents. Other than that, respondents were found that they are more easily to sweat at very high temperature which cause them feel uncomfortable with the sticky skin condition. The sticky skin lowers their performance and decrease the productivity rate. Besides that, some of the respondents felt too cold at temperature 24°C with only one shirt, and some of them felt that they need more energy to perform the task (loading and unloading 25kg task) and which can cause muscle fatigue easily. Apart from that, illuminance does not affect the muscle activities much from the final findings. Therefore, it maybe can conclude as the job element doesn't need a high illuminance to perform their task like teacher needs a high illuminance level to read their books. In a nutshell, temperature 24°C is the suitable temperature for workers to perform their task while the illuminance level does not affect much in this task of the research.

Table.1 Illuminance at 200 lux

Factor	Unit	Low	Medium	High
Temperature	^{o}C	19	24	32

Table.2 The summarization of correlation relationship of right body side and left body side

Illuminance Level	Temperature	Right body side (Right Biceps brachii to Righ Trapezius)	Left body side (Left Biceps brachii to Left Trapezius)
200lux	32°C	-0.5008 *(medium)*	-0.7527 *(strong)*
	24°C	-0.3849 *(weak)*	0.15 *(very weak)*
	19°C	0.1532 *(very weak)*	-0.3438 *(weak)*

Figure.1 Electromyography signal and movement indication

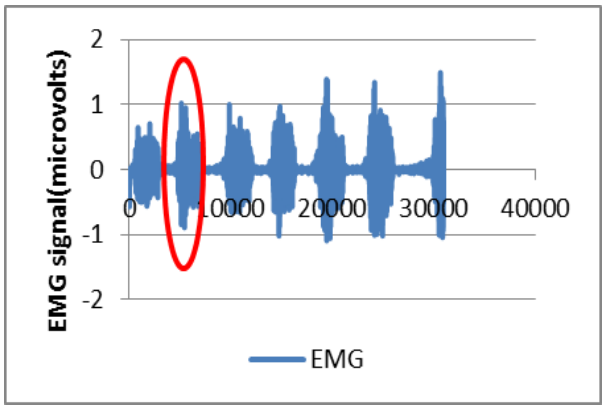


Figure.2 EMG Reading Of Muscles Activities at Constant Illuminance And Dominant Temperature Setting

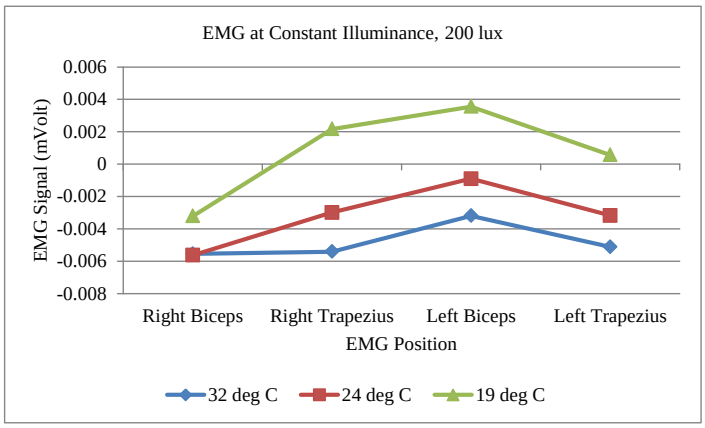


Figure.3a EMG reading of muscles activities at constant temperature 32°C and illuminance 200lux

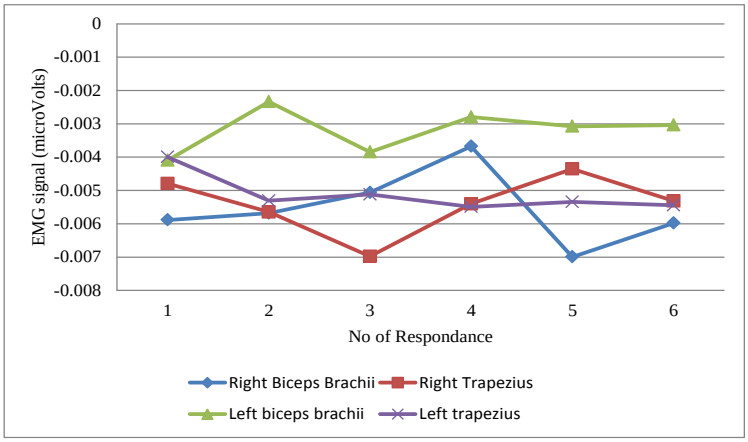


Figure.3b EMG reading of muscles activities at constant temperature 24°C and illuminance 200lux

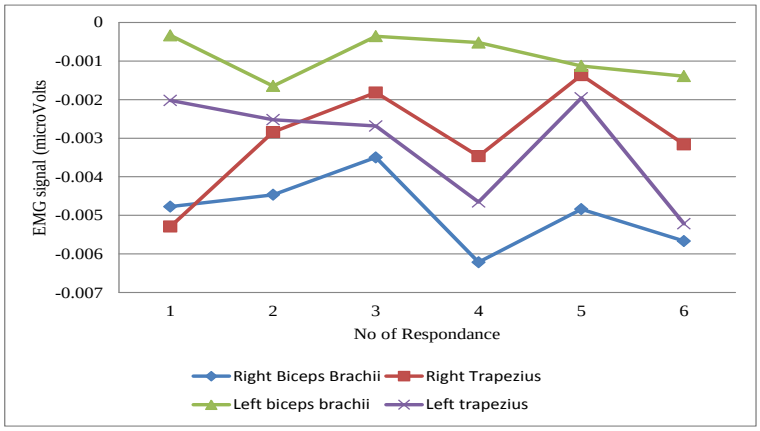
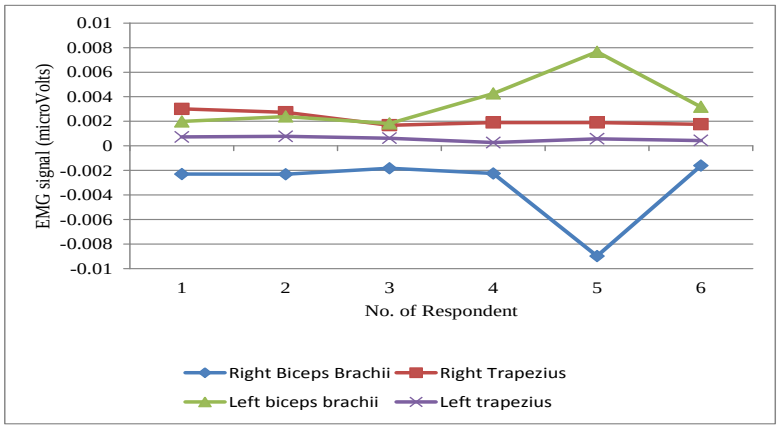


Figure.3c EMG reading of muscles activities at constant temperature 24°C and illuminance 200lux



Acknowledgement

Apart from this research, we would like to thank all subjects who volunteered to participate in this study especially Mr Abdelhakim Deboucha from Faculty of Mechanical Engineering UMP, Department of Occupational Safety and Health (DOSH), Pahang State and Felda Rubber Industry Kampung Awah, Temerloh for their support and contribution in this particular study.

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